Center Innovation Fund: JPL CIF

# Nonlinear Optical Terahertz Technology

Completed Technology Project (2011 - 2012)

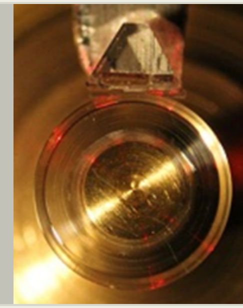
## Project Introduction

We develop a new approach to generation of THz radiation. Our method relies on mixing two optical frequency beams in a nonlinear crystalline Whispering Gallery Mode (WGM) resonator to generate difference frequency polarization in THz range. Metallic structure is used to produce constructive interference of radiation from multiple THz dipoles in the far field. Compact design and high efficiency makes this technology suitable for space and other applications which have demanding requirements.

Our approach is based on high-Q optical WGM resonators made with a nonlinear crystal. Such resonators have been demonstrated to dramatically enhance nonlinear optical processes involving optical, microwave and THz frequencies. Difference frequency polarization is generated from two optical beams via second order nonlinearity of lithium niobate (LN). Efficient difference frequency generation (DFG) requires three features. The optical beams should be near the surface due to large THz absorption coefficient of lithium niobate. The cross section of the optical beams must be smaller than THz wavelength to minimize far field phase mismatch of the THz beam. In addition, the optical beam intensities must be high for the conversion process to be efficient. The LN WGM resonators provide the highest figures of merit on all three requirements and are expected to outperform the Fabry-Perot resonator-based nonlinear optical THz generation. The required phase matching of the process is achieved with a structure represented either by the periodically poled domains or by a metal structure integrated with a resonator. The capability to produce micrometer-precision arbitrary domains in ferroelectric crystal chips is present at JPL. With collaboration at UCSB/ITST we fabricated metal structures on LN chip. These chips were then used at JPL to produce WGM resonators with an integrated metal phase matching structure. Intrinsic Q of these resonators was preserved at 10 million levels which is an important milestone. We then carried out an experiment aimed at simultaneous excitation of two whispering gallery modes inside the resonator. The outputs of two DFB lasers emitting at 1560 nm and 1548 nm (1.5 THz difference frequency) are combined and are coupled to the resonator with a prism coupler. Coupling efficiency exceeded 40 %. We achieved two-wavelength pumping of the resonator and high optical Q.

## Anticipated Benefits

High power THz local oscillators and detectors as components of THz imagers, capable of multi-pixel integration, are essential for future and funded space missions. Current science tasks of operational space flown instruments such as MIRO, SOFIA establish the need for the compact power efficient THz components. The project addresses NASA research objective “Understand the processes that determine the history and future of habitability in the solar system”.



Project Image Nonlinear Optical Terahertz Technology

## Table of Contents



## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Jet Propulsion Laboratory (JPL)

**Responsible Program:**

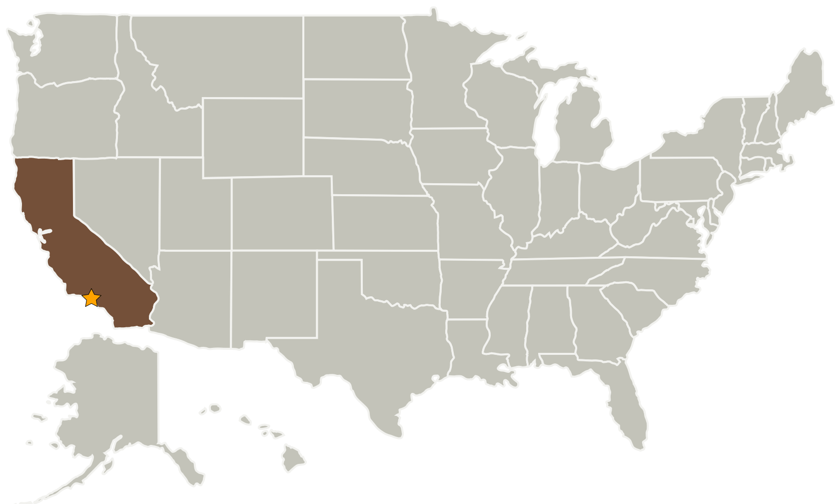
Center Innovation Fund: JPL CIF

Center Innovation Fund: JPL CIF

# Nonlinear Optical Terahertz Technology

Completed Technology Project (2011 - 2012)

## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Jet Propulsion Laboratory(JPL) | Lead Organization | NASA Center | Pasadena, California |

| Co-Funding Partners | Type | Location |
|---|---|---|
| UC Santa Barbara - Institute for Terahertz Science and Technology(ITST: UCSB) | Academia | Santa Barbara, California |

| Primary U.S. Work Locations |
|---|
| California |

## Project Management

**Program Director:**
Michael R Lapointe

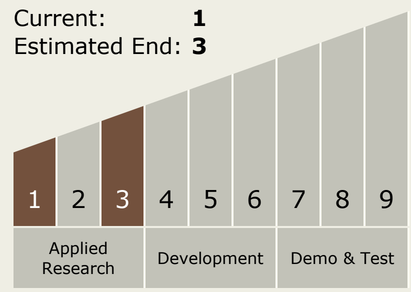
**Program Manager:**
Fred Y Hadaegh

**Project Manager:**
Jonas Zmuidzinas

**Principal Investigator:**
Ivan S Grudinin

## Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **3**




## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.5 Lasers

## Images

**60.png**
Project Image Nonlinear Optical Terahertz Technology
*(https://techport.nasa.gov/image/1155)*